Model-based Testability Assessment and Directed Troubleshooting of Shuttle Wiring Systems

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We have recently completed a pilot study on the Space shuttle wiring system commissioned by the **W**iring **I**ntegrity **Re**seach (WIRe) team at NASA Ames Research Center. As the space shuttle ages, it is experiencing wiring degradation problems including arcing, chaffing, insulation breakdown and broken conductors. A systematic and comprehensive test process is required to thoroughly test and quality assure (QA) the wiring systems. The NASA WIRe team recognized the value of a formal model based analysis for risk assessment and fault coverage analysis. However, wiring systems are complex and involve over 50,000 wire segments. Therefore, NASA commissioned this pilot study with Qualtech Systems, Inc. (QSI) to explore means of automatically extracting high fidelity multisignal models from wiring information database for use with QSI s Testability Engineering and Maintenance System (TEAMS) tool.

We began by creating a TEAMS model for a subset of the shuttle wiring which would contain the necessary information to diagnose and repair wiring problems within a Shuttle subsystem. The MEC1 Shuttle subsystem was the subject of this study. All of the wiring information required for creating the wiring model was supplied via a Shuttle Connector Analysis Network (SCAN) electronic wirelist. This partial wirelist contained all the wiring information relative to the MEC1 assembly. Using this NASA supplied SCAN wirelist, QSI concurrently created manual and automatically generated wiring models for all wire paths associated with connector J3 on the MEC1 assembly. The manually generated model helped establish the rules of modeling. The automated model was compared against the manual model to verify that the automatically generated model accurately portrayed the actual wiring configuration for connector J3. Once it was ascertained that the automatically generated model was identical to the one created manually, the complete MEC1 model was generated, thus saving significant modeling cost. The methodology is easily extensible to the entire shuttle wiring system. Failure modes modeled include pushed pin and bent pins of connectors, opens and shorts of conductors, high voltage dielectric breakdown and impedance mismatch and noise pickup due to cable degradation. Tests modeled include continuity and isolation checks, resistance and impedance measurements, and dielectric withstanding voltage tests. To perform these tests one or more connectors have to be de-mated and the test equipment have to be connected to the open connectors. The mating and de-mating of connectors

was modeled using switches and modes. Thus, TEAMS could assess the test coverage and fault isolation of the wiring system given the mate-demate status of the connectors, which is tracked by the SCAN database.

Since many wiring problems are intermittent and only manifest under specific operational conditions, the idea of onboard, continuous monitoring of wire health utilizing TEAMS-RT, QSI s real-time embedded diagnostic engine, was also proposed.

We demonstrated the use of these models by TEAMATE, a portable maintenance aid, to guide a technician through a systematic testing procedure to achieve maximum fault coverage while minimizing test cost and times. The TEAMATE runtime software supports thin clients (e.g., wireless handheld devices) and can be conveniently used to instruct and track test procedures and configuration changes of the shuttle. TEAMATE can also be utilized to guide multiple concurrent automated testers to improve test efficiency. The TEAMS toolset can be used in conjunction with COTS automated testing tools, which already provide the connectivity between the test program and the ATE. TEAMS could also output the test sequence directly in the format (language) required by the ATE. The utility of each approach should be studied to determine the most effective process.

This paper presents our modeling and analysis results from the pilot study along with our proposed solutions to the complex issues of wiring integrity assessment problem.